

WHAT IS CLAIMED IS:

1 1. A method of etching a noble metal layer disposed on a substrate
2 comprising the steps of:
3 a) providing a substrate supporting a barrier layer, a noble
4 metal layer on said barrier layer, a protective layer on said noble metal layer, a mask layer
5 on said protective layer, and a patterned resist layer on said mask layer;
6 b) etching a portion of said mask layer including employing a
7 plasma of a mask etchant gas to break through and to remove said portion of said mask
8 layer from said protective layer to expose part of said protective layer and to produce said
9 substrate supporting said barrier layer, said noble metal layer on said barrier layer, said
10 protective layer on said noble metal layer, a residual mask layer on said protective layer,
11 and said patterned resist layer on said residual mask layer;
12 c) removing said patterned resist layer from said residual mask
13 layer of step (b) to produce said substrate supporting said barrier layer, said noble metal
14 layer on said barrier layer, said protective layer on said noble metal layer, and said
15 residual mask layer on said protective layer;
16 d) etching said exposed part of said protective layer to expose
17 part of said noble metal layer and to produce said substrate supporting said barrier layer,
18 and said noble metal layer on said barrier layer, a residual protective layer on said noble
19 metal layer, and said residual mask layer on said residual protective layer;
20 e) heating said substrate of step (d) to a temperature greater
21 than about 150°C;
22 f) etching said exposed part of said noble metal layer of step
23 (d) including employing a plasma of an etchant gas selected from the group consisting of
24 a halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to produce
25 said substrate supporting said barrier layer, an etched noble metal layer on said barrier
26 layer, said residual protective layer on said etched noble metal layer, and said residual
27 mask layer on said residual protective layer;
28 g) removing said residual mask layer from said residual
29 protective layer to produce said substrate supporting said barrier layer, said etched noble
30 metal layer on said barrier layer, and said residual protective layer on said etched noble
31 metal layer; and

32 h) etching a portion of said barrier layer including employing
33 a plasma of a barrier etchant gas to expose part of the substrate to produce said substrate
34 supporting a residual barrier layer, said etched noble metal layer on said residual barrier
35 layer, and said residual protective layer on said etched noble metal layer.

1 2. The method of Claim 1 wherein said step (f) etching of said noble
2 metal layer of step (d) additionally produces a remaining noble metal layer on said barrier
3 layer, said step (g) removing of said residual mask layer additionally produces said
4 remaining noble metal layer on said barrier layer, and said method additionally comprises
5 etching said remaining noble metal layer on said barrier layer prior to said step (h)
6 etching.

1 3. The method of Claim 1 additionally comprising removing said
2 residual protective layer from said etched noble metal layer.

1 4. The method of Claim 1 wherein said step (f) etching of said noble
2 metal layer of step (d) additionally produces a remaining noble metal layer on said barrier
3 layer, said step (g) removing of said residual mask layer additionally produces said
4 remaining noble metal layer on said barrier layer, and said method additionally comprises
5 etching said residual protective layer and said remaining noble metal layer on said barrier
6 layer prior to said step (h) etching.

1 5. The method of Claim 3 wherein said removing of said residual
2 protective layer from said etched noble metal is simultaneous with said etching step (h).

1 6. The method of Claim 1 wherein said mask layer comprises CVD
2 SiO₂.

1 7. The method of Claim 2 wherein said mask layer and said substrate
2 comprises CVD SiO₂.

1 8. The method of Claim 4 wherein said mask layer comprises CVD
2 SiO₂.

1 9. The method of Claim 1 wherein said mask layer comprises a
2 compound selected from the group consisting of TEOS, CVD SiO₂, Si₃N₄, BSG, PSG,

3 BPSG, a low dielectric constant material with a dielectric constant less than about 3.0,
4 and mixtures thereof.

1 10. The method of Claim 1 wherein said barrier layer comprises a
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,
3 and mixtures thereof.

1 11. The method of Claim 1 wherein said protective layer comprises a
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,
3 and mixtures thereof.

1 12. The method of Claim 1 wherein said mask layer has a thickness
2 ranging from about 6000Å to about 9,000Å.

1 13. A method of etching a noble metal layer disposed on a substrate
2 comprising the steps of:

3 a) providing a substrate supporting a barrier layer, a noble
4 metal layer on said barrier layer, a mask layer on said noble metal layer, and a patterned
5 resist layer on said mask layer;

6 b) etching a portion of said mask layer including employing a
7 plasma of a mask etchant gas to break through and to remove said portion of said mask
8 layer from said noble metal layer to expose part of said noble metal layer and to produce
9 said substrate supporting said barrier layer, said noble metal layer on said barrier layer, a
10 residual mask layer on said noble metal layer, and said patterned resist layer on said
11 residual mask layer;

12 c) removing said patterned resist layer from said residual mask
13 layer of step (b) to produce said substrate supporting said barrier layer, said noble metal
14 layer on said barrier layer, and said residual mask layer on said noble metal layer;

15 d) heating said substrate of step (c) to a temperature greater
16 than about 150°C;

17 e) etching said exposed part of said noble metal layer of step
18 (c) including employing a plasma of an etchant gas selected from the group consisting of
19 a halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to produce
20 said substrate supporting said barrier layer, an etched noble metal layer on said barrier
21 layer, and said residual mask layer on said etched noble metal layer;

22 f) removing said residual mask layer from said etched noble
23 metal layer to produce said substrate supporting said barrier layer and said etched noble
24 metal layer on said barrier layer; and

25 g) etching a portion of said barrier layer including employing
26 a plasma of a barrier etchant gas to expose part of the substrate to produce said substrate
27 supporting a residual barrier layer and said etched noble metal layer on said residual
28 barrier layer.

1 14. A method of etching a noble metal layer disposed on a substrate
2 comprising the steps of:

3 a) providing a substrate supporting a barrier layer, a noble
4 metal layer on said barrier layer, a protective layer on said noble metal layer, a mask layer
5 on said protective layer, and a patterned resist layer on said mask layer;

6 b) etching a portion of said mask layer including employing a
7 plasma of a mask etchant gas to break through and to remove said portion of said mask
8 layer from said protective layer to expose part of said protective layer and to produce said
9 substrate supporting said barrier layer, said noble metal layer on said barrier layer, said
10 protective layer on said noble metal layer, a residual mask layer on said protective layer,
11 and said patterned resist layer on said residual mask layer;

12 c) removing said patterned resist layer from said residual mask
13 layer of step (b) to produce said substrate supporting said barrier layer, said noble metal
14 layer on said barrier layer, said protective layer on said noble metal layer, and said
15 residual mask layer on said protective layer;

16 d) etching said exposed part of said protective layer to expose
17 part of said noble metal layer and to produce said substrate supporting said barrier layer,
18 said noble metal layer on said barrier layer, a residual protective layer on said noble metal
19 layer, said residual mask layer on said residual protective layer, and said patterned resist
20 layer on said residual mask layer;

21 e) heating said substrate of step (d) to a temperature greater
22 than about 150°C;

23 f) etching said exposed part of said noble metal layer of step
24 (d) including employing a plasma of an etchant gas selected from the group consisting of
25 a halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to produce
26 said substrate supporting said barrier layer, an etched noble metal layer on said barrier

27 layer, said residual protective layer on said etched noble metal layer, and said residual
28 mask layer on said residual protective layer;

29 g) etching a portion of said barrier layer including employing
30 a plasma of a barrier etchant gas to expose part of the substrate to produce said substrate
31 supporting a residual barrier layer, said etched noble metal layer on said residual barrier
32 layer, said residual protective layer on said etched noble metal layer, and said residual
33 mask layer on said residual protective layer; and

34 h) removing said residual mask layer from said residual
35 protective layer to produce said substrate supporting said residual barrier layer, said
36 etched noble metal layer on said residual barrier layer, and said residual protective layer
37 on said etched noble metal layer.

1 15. The method of Claim 14 wherein said barrier layer comprises a
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,
3 and mixtures thereof.

1 16. The method of Claim 14 wherein said protective layer comprises a
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,
3 and mixtures thereof.

1 17. The method of Claim 14 wherein said mask layer has a thickness
2 ranging from about 6000Å to a about 9,000Å.

1 18. The method of Claim 14 wherein said mask layer comprises a
2 compound selected from the group consisting of Si₃N₄, BSG, PSG, BPSG, a low
3 dielectric constant material with a dielectric constant of less than about 3.0, and mixtures
4 thereof.

1 19. A method of etching a noble metal layer disposed on a substrate
2 comprising the steps of:

3 a) providing a substrate supporting an etch-stop layer, a
4 barrier layer on said etch-stop layer, a noble metal layer on said barrier layer, a mask
5 layer on said noble metal layer, and a patterned resist layer on said mask layer;
6 b) etching a portion of said mask layer including employing a
7 plasma of a mask etchant gas to break through and to remove said portion of said mask
8 layer from said noble metal layer to expose part of said noble metal layer and to produce

9 said substrate supporting said etch-stop layer, said barrier layer on said etch-stop layer,
10 said noble metal layer on said barrier layer, a residual mask layer on said noble metal
11 layer, and said patterned resist layer on said residual mask layer;

12 c) removing said patterned resist layer from said residual mask
13 layer of step (b) to produce said substrate supporting said etch-stop layer, said barrier
14 layer on said etch-stop layer, said noble metal layer on said barrier layer, and said residual
15 mask layer on said noble metal layer;

16 d) heating said substrate of step (c) to a temperature greater
17 than about 150°C;

18 e) etching said exposed part of said noble metal layer
19 including employing a plasma of an etchant gas selected from the group consisting of a
20 halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to expose
21 part of the barrier layer and to produce said substrate supporting said etch-stop layer, said
22 barrier layer on said etch-stop layer, an etched noble metal layer on said barrier layer, and
23 said residual mask layer on said etched noble metal layer;

24 f) etching said exposed part of said barrier layer to expose part
25 of said etch-stop layer and to produce said substrate supporting said etch-stop layer, a
26 residual barrier layer on said etch-stop layer, said etched noble metal layer on said
27 residual barrier layer, and said residual mask layer on said etched noble metal layer; and

28 g) removing said residual mask layer from said etched noble
29 metal layer to produce said substrate supporting said etch-stop layer, said residual barrier
30 layer on said etch-stop layer, and said etched noble metal layer on said residual barrier
31 layer.

1 20. The method of Claim 19 additionally comprising etching said etch-
2 stop layer.

1 21. The method of Claim 19 wherein said mask layer comprises a
2 compound selected from the group consisting of CVD SiO₂, TEOS, BSG, PSG, BPSG, a
3 low dielectric constant material with a dielectric constant of less than about 3.0.

1 22. A method of etching a noble metal layer disposed on a substrate
2 comprising the steps of:

3 a) providing a substrate supporting a barrier layer, a noble
4 metal layer on said barrier layer, a first mask layer on said noble metal layer, a second

5 mask layer on said first mask layer, and a patterned resist layer on said second mask
6 layer;

7 b) etching a portion of said second mask layer including
8 employing a plasma of a mask etchant gas to break through and to remove said portion of
9 said second mask layer from said first mask layer to expose part of said first mask layer
10 and to produce said substrate supporting said barrier layer, said noble metal layer on said
11 barrier layer, said first mask layer on said noble metal layer, a residual second mask layer
12 on said first mask layer, and said patterned resist layer on said residual second mask
13 layer;

14 c) etching said exposed part of said first mask layer to expose
15 part of said noble metal layer and to produce said substrate supporting said barrier layer,
16 said noble metal layer on said barrier layer, a residual first mask layer on said noble metal
17 layer, said residual second mask layer on said residual first mask layer, and said patterned
18 resist layer on said residual second mask layer;

19 d) removing said patterned resist layer from said residual
20 second mask layer of step (c) to produce said substrate supporting said barrier layer, said
21 noble metal layer on said barrier layer, and said residual first mask layer on said noble
22 metal layer, and said residual second mask layer on said first residual mask layer;

23 e) heating said substrate of step (d) to a temperature greater
24 than about 150°C;

25 f) etching said exposed part of said noble metal layer and said
26 residual second mask layer of step (d) including employing a plasma of an etchant gas
27 selected from the group consisting of a halogen containing gas, a noble gas, nitrogen,
28 oxygen, and mixtures thereof, to produce said substrate supporting said barrier layer, an
29 etched noble metal layer on said barrier layer, and said residual first mask layer on said
30 etched noble metal layer;

31 g) etching said barrier layer to remove a portion of the barrier
32 layer from said substrate to produce said substrate supporting a residual barrier layer, said
33 etched noble metal layer on said residual barrier layer, and said residual first mask layer
34 on said etched noble metal; and

35 h) removing said residual first mask layer from said etched
36 noble metal layer to produce said substrate supporting said residual barrier layer, and said
37 etched noble metal layer on said residual barrier layer.

1 23. The method of Claim 22 wherein said patterned resist layer is
2 removed from said residual second mask layer during said etching step (c).

1 24. The method of Claim 22 wherein said first mask layer comprises a
2 compound selected from the group consisting of Si_3N_4 , BSG, PSG, BPSG, an organic
3 polymer, a low dielectric constant material having a dielectric constant of less than about
4 3.0, and mixtures thereof.

1 25. The method of Claim 22 wherein said second mask layer comprises
2 a compound selected from the group consisting of CVD SiO_2 , TEOS, Si_3N_4 , BSG, PSG,
3 BPSG, SiC, and mixtures thereof.

1 26. The method of Claim 22 wherein said first mask layer has a
2 thickness ranging from about 3000Å to about 8000Å.

1 27. The method of Claim 22 wherein said second mask layer has a
2 thickness ranging from about 500Å to about 4000Å.

1 28. The method of Claim 22 wherein said etching step (g) additionally
2 comprises etching into said substrate.